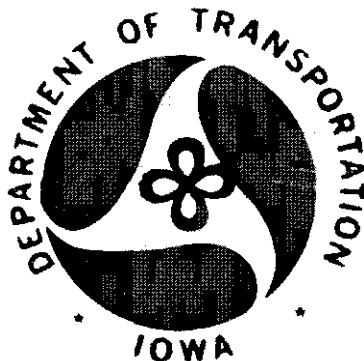


PAVEMENT WEAR AND STUDDED TIRE USE IN IOWA

**FINAL REPORT
IOWA HIGHWAY RESEARCH BOARD
Project HR-148**



**HIGHWAY DIVISION
June 1979**

DISCLAIMER

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PAVEMENT WEAR
AND
STUDED TIRE USE
IN
IOWA

FINAL REPORT

IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-148

BY

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HIGHWAY DIVISION
IOWA DEPARTMENT OF TRANSPORTATION
AMES, IOWA 50010

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PAVEMENT WEAR AND STUDDED TIRE USE IN IOWA

INTRODUCTION

The use of studded tires became legal in Iowa in 1967 from November 1 of each year to April 1 of the following year. It was soon recognized that the wheel paths of some of the Interstate highways were beginning to exhibit increased wear. Also, there has been a continuing controversy regarding their benefits when all aspects of highway safety are considered.

The Iowa Highway Research Board approved a proposal titled, "Investigation of Pavement Wear in Relation to the Use of Studded Tires" in August of 1969 which was subsequently approved by the Iowa State Highway Commission.

One phase of the project was financial participation in a research project conducted by the American Oil Company on pavement wear due to studded tires for the State of Minnesota. This project was conducted at the laboratory and test track operated by the American Oil Company at Whiting, Indiana. The laboratory tests showed that studded tires without sand and salt abraded the pavement specimens more than 100 times as rapidly as unstudded tires with sand and salt.

The second phase was to be a limited investigation to determine pavement wear and studded tire usage in Iowa. This was to

include a survey to determine studded tire usage in Iowa and measurement of transverse pavement profiles at selected locations where the pavement is subjected to a high volume of traffic. This report concerns this phase of the research project.

STUDDED TIRE USAGE

Surveys of studded tire use in Iowa were made by field personnel of the Iowa DOT in January of each of the years 1969 through 1978. The surveys were made by observing tires on vehicles parked in parking lots, both public and private and on the streets.

To determine the statewide average, the state was divided into 27 areas as shown in Figure 1. The number of cars using studded tires in each area was determined as follows:

$$\frac{\text{Number of cars with studded tires}}{\text{Number of cars observed}} \times \text{Number of cars registered in area}$$

The number of vehicles observed and percentage of vehicles statewide with studded tires for each of the survey years are presented in Table I. The total survey for the 1977-78 winter is in the Appendix.

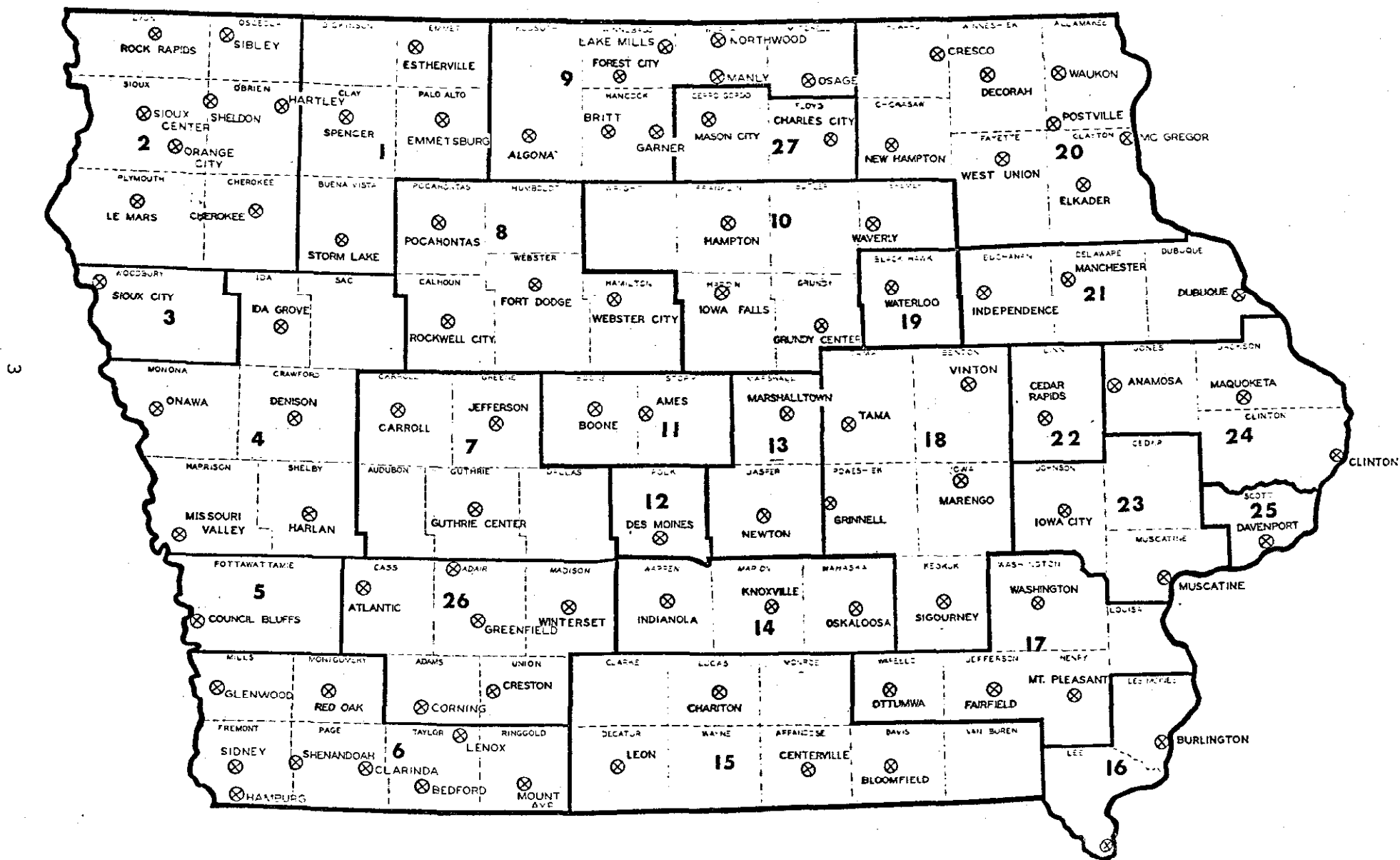


Figure 1. Studded Tire Survey Areas

TABLE I

Studded Tire Use in Iowa - 10 years
(Parked Vehicle Surveys)

<u>Winter Period</u>	<u>Total Number Vehicles Observed</u>	<u>Percent Vehicles With Studded Tires</u>
1968-69	13,972	7.4
1969-70	21,462	15.8
1970-71	30,063	22.6
1971-72	69,150	21.5
1972-73	71,810	19.7
1973-74	71,583	17.1
1974-75	73,963	14.8
1975-76	74,896	12.6
1976-77	70,943	8.2
1977-78	69,482	8.5

Estimates of studded tire usage were also made at various locations on Interstate highways in Iowa. These were determined from surveys of moving vehicles where the presence of studded tires was evidenced by the sound of the studs striking the pavement. These surveys were made by the Office of Planning. The results of these surveys are shown in Table II. There is relatively close agreement with the counts made in the area parking lots.

As noted in Table I, the lowest percentage of studded tires was observed in the initial count during the winter of 1968-69. Two (2) years later the percentage had increased to the maximum (22.6%) and then began a gradual decline. The latest count in January of 1978 indicated 8.5% of the cars had studded tires.

A bill to ban studded tires was introduced in the 1972 Legislature and each legislative session since that time. The decline in the use of studded tires is attributed to the efforts of the Iowa DOT and others to obtain a ban on studded tires and a continual increase in the use of radial tires with claims of improved traction.

WEAR MEASUREMENT

The measurements were made by placing a four foot metal straightedge across the wheel path. The pavement wear (the

TABLE II
Studded Tire Use in Iowa
Interstate Highways
(Moving Vehicle Surveys)

<u>Location</u>	<u>% Vehicles With Studded Tires</u>			
	<u>1970-71</u>	<u>1971-72</u>	<u>1972-73</u>	<u>1973-74</u>
I-29 North of Onawa	21.6	21.8	27.8	8.9
I-29 Sioux City	26.7	26.0	18.4	5.9
I-35 Hamilton Co.	23.7	21.5	12.8	9.4
I-35 E. of Merle Hay	28.6	16.3	17.3	16.0
I-35 S. of Rider Corner	24.8	17.6	18.2	20.8
I-35 Warren Co.	21.1	12.6	15.3	9.6
I-35 Clarke Co.	28.4	17.0	16.7	8.4
I-74 Davenport	19.9	20.8	15.2	8.1
I-80 Neola	28.1	21.9	26.1	11.3
I-80 Minden	30.9	23.5	23.6	12.0
I-80 W. of Menlo	31.2	16.7	11.4	9.9
I-80 E. of Menlo	32.0	17.4	16.2	9.2
I-80 W. of Marengo	19.0	21.1	20.4	8.5
I-80 W. of Williamsburg	19.6	25.3	19.3	8.6
TOTAL	25.6	19.2	18.0	11.7

distance between the bottom of the straightedge and the surface of the pavement) was measured at five (5) points spaced eight (8) inches apart across the width of the wheel path.

The measurement device is shown in Figure 2. The measurements are recorded to the nearest 1/16 inch which is believed to be the accuracy of the device. Traffic and weather conditions sometimes make it difficult to obtain rapid accurate measurements. For this reason, the measurements were recorded by a camera positioned at a fixed distance from the straightedge.

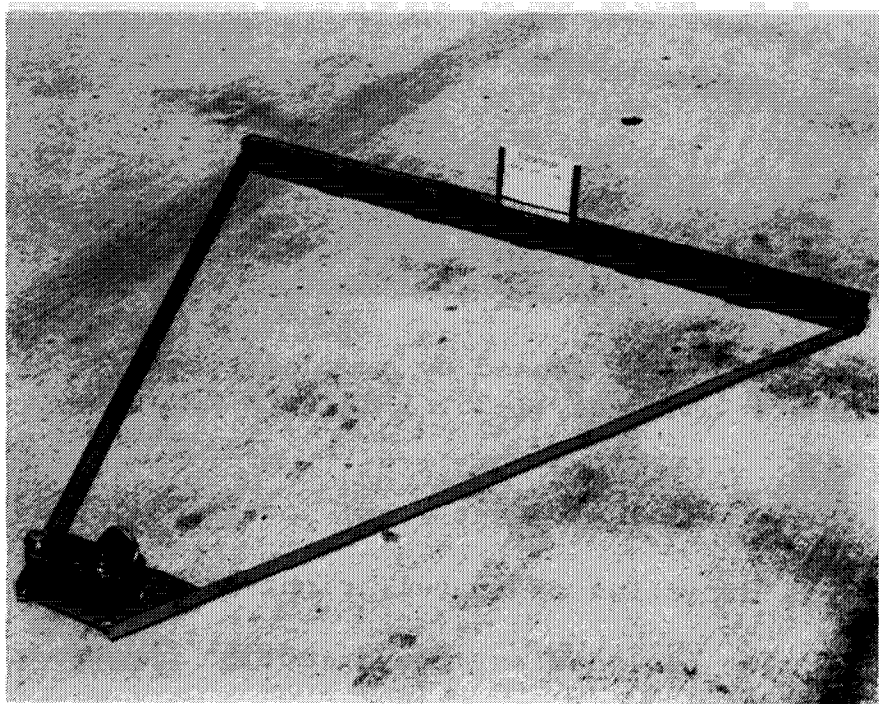


Figure 2: Device for measuring studded tire wear.

Examples of pavement wear, as revealed by the straight-edge, may be observed in Figures 3, 4 and 5. The measurements are obtained by noting the position of the five (5) pins relative to the short white markers that appear on the straight-edge. Each mark on the straightedge is 1/8 inch. The top of the upper white mark is zero.

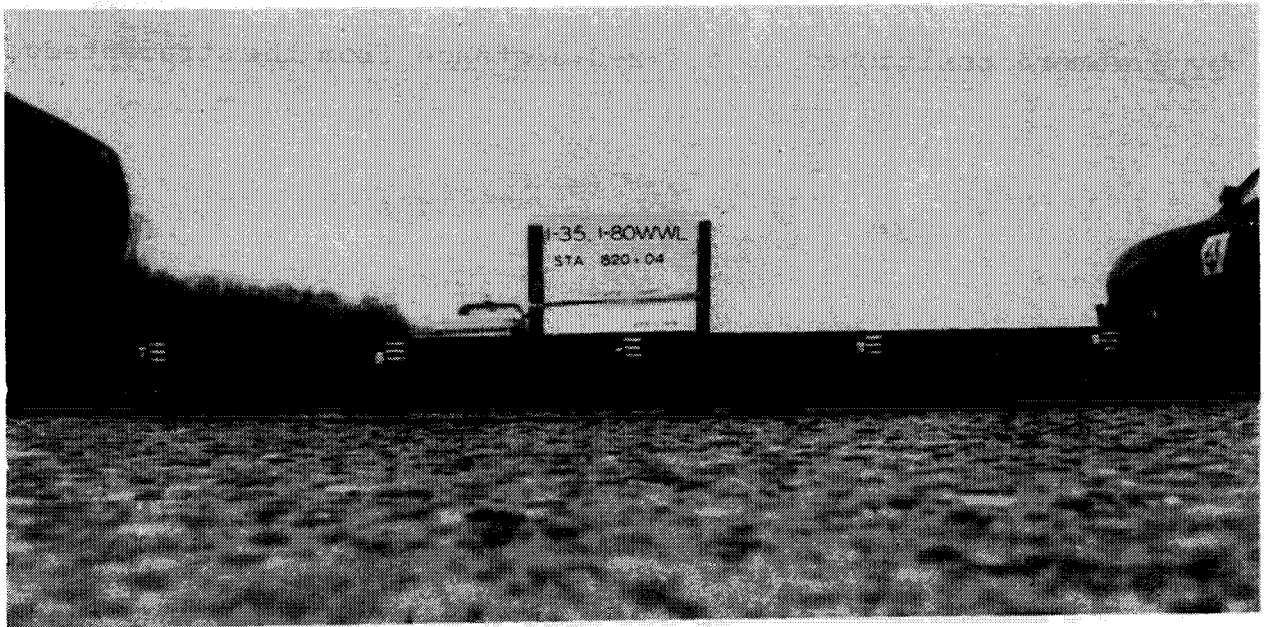


Figure 3: Pavement wear caused by studded tires of portland cement concrete, I-35, I-80 Polk County

Each picture shows pavement wear, location, including highway number, direction of travel, right or left wheel path and station. Also included are the direction the camera is facing and the month and year.



Figure 4: Pavement wear caused by studded tires of portland cement concrete, Des Moines Freeway

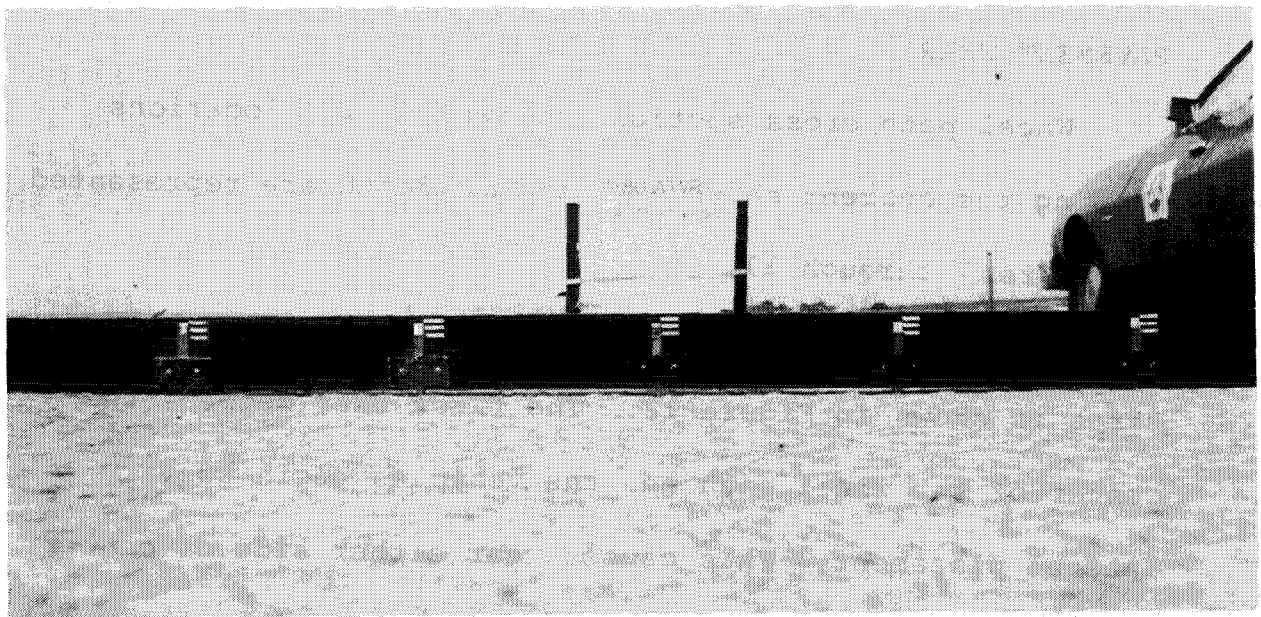


Figure 5: Pavement wear caused by studded tires on portland cement concrete, I-80 near Avoca

With this information noted on each picture, each pin on the straightedge will always represent the same location in the wheel path. Information sheets with this information as well as the distance from the edge of the pavement to the end of the straightedge (Figure 6) were taken for reference during data collection.

The recorded measurements are an average of three (3) measurements made at each location. An example being a measurement recorded for Station 820+00 is an average of measurements made at 819+96, 820+00 and 820+04. This method was used to reduce the possibility of small surface variations in the pavement being used as a recorded measurement.

PAVEMENT WEAR

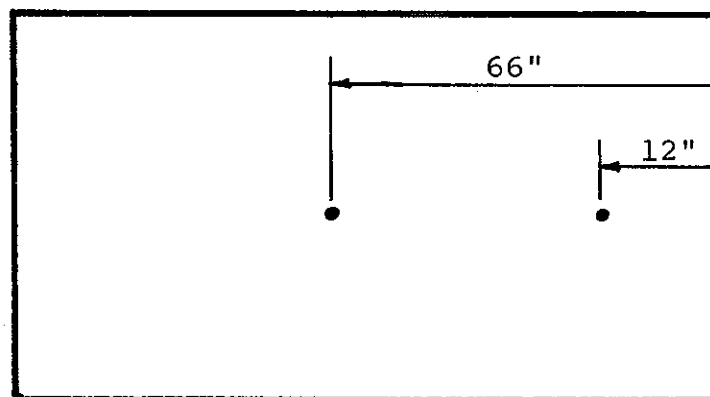
Wheel path cross sections at twelve (12) locations showing the current shape and maximum depth are represented in Figures 7 through 11.

The progression of wheel path shape caused by studded tires is shown in Figure 12. The first wear deepens the center of the wheel path and the vehicles begin to vary lateral placement. This causes wear either side of center of the wheel path, resulting in a wider bottom in the wheel path and then it begins again with the center being deepened and then the bottom is widened again.



I-235 Just west of Cottage Grove (Looking west)

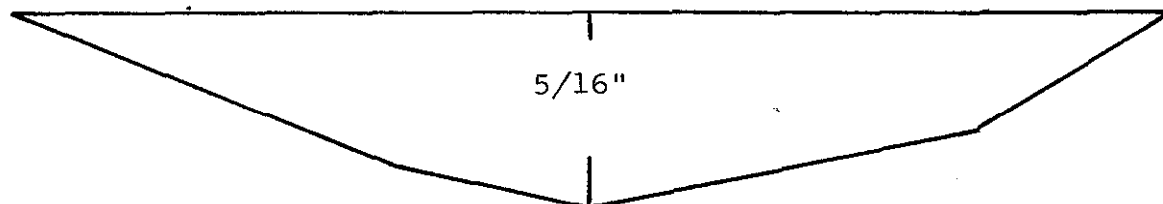
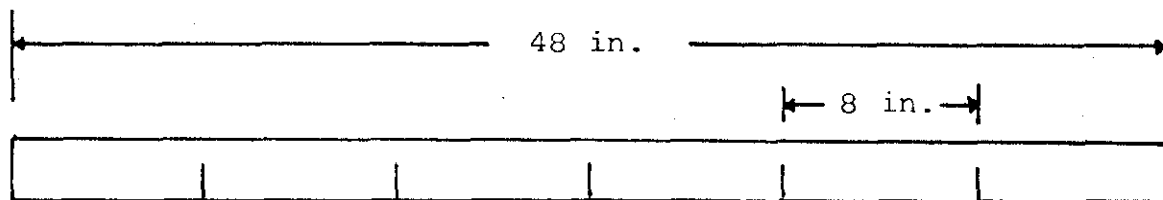
Eastbound Left Center Lane



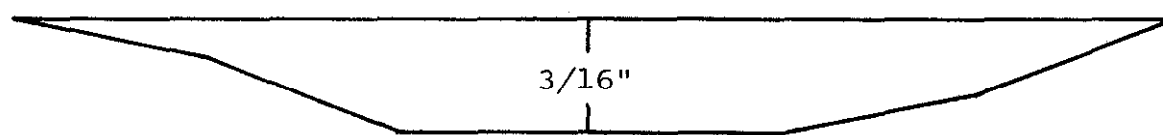
384 + 00



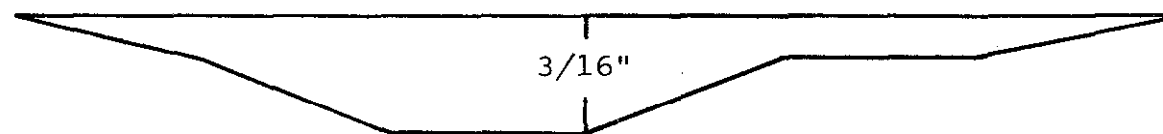
Figure 6: Information Sheet



I-235 Northbound - Station 384+00

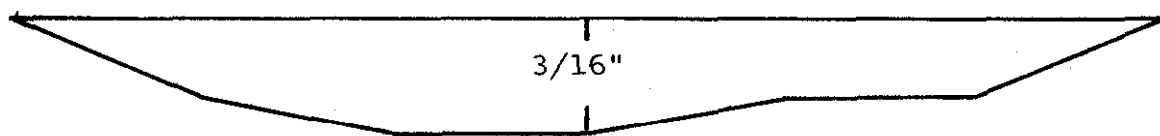
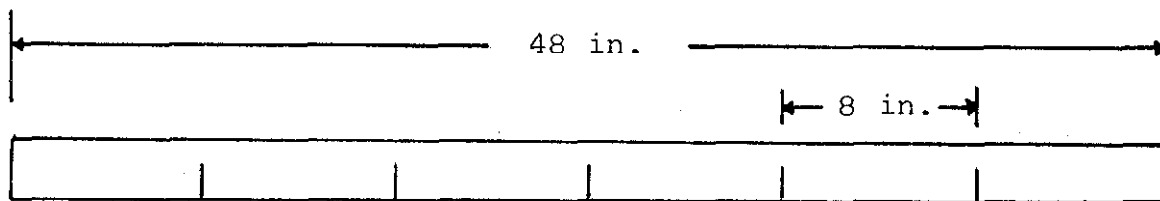


I-235 Southbound - Station 507+00

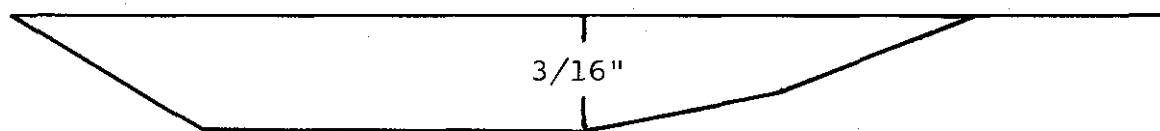


I-235 Northbound - Station 655+00

Figure 7: Wheel Path Cross Sections - 1979

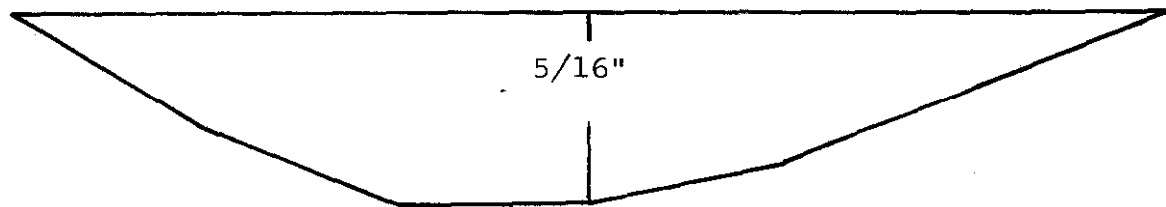
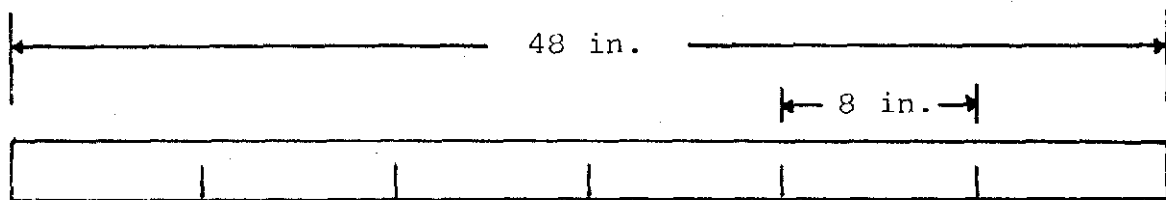


I-35 Southbound in Warren County

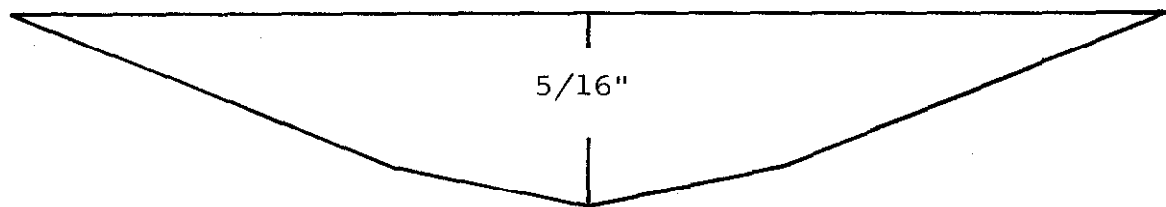


I-35 Northbound in Warren County

Figure 8: Wheel Path Cross Sections - 1979

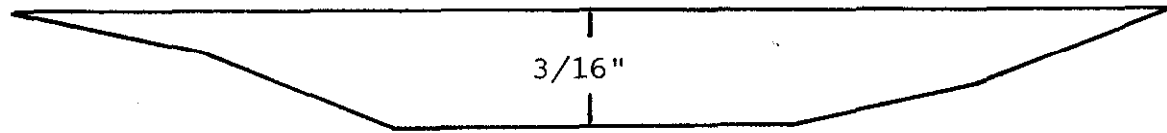
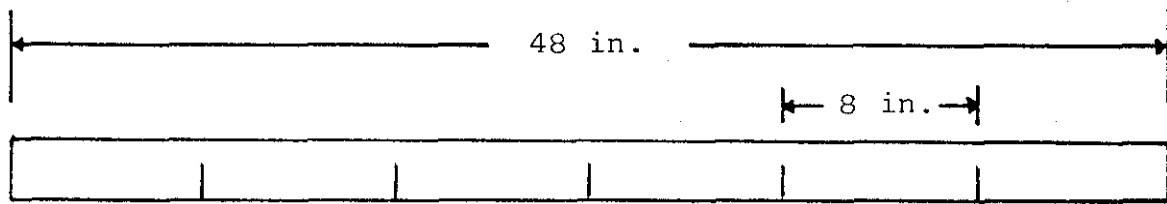


I-35, I-80 Westbound North of Des Moines

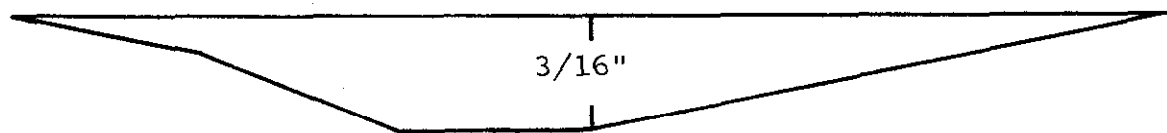


I-35, I-80 Eastbound North of Des Moines

Figure 9: Wheel Path Cross Sections - 1979

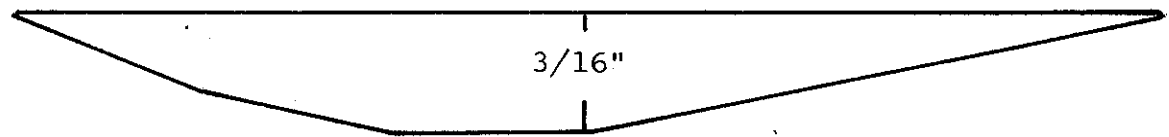
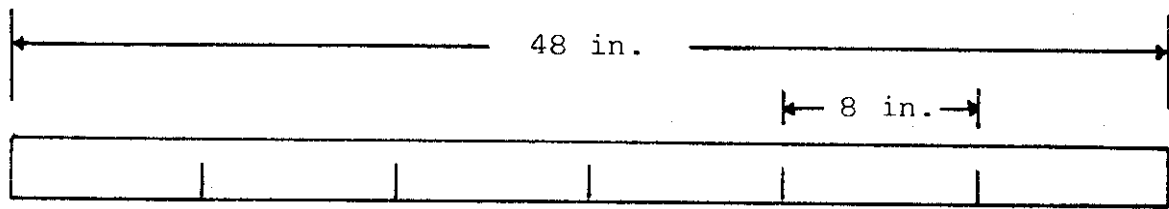


I-80 Westbound near Avoca

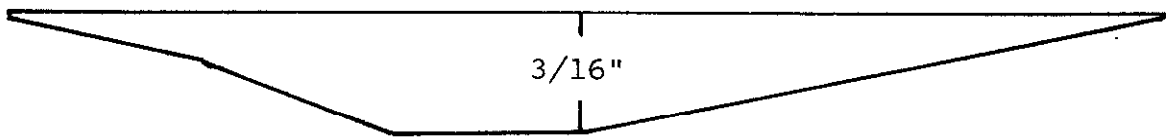


I-80 Westbound near Minden

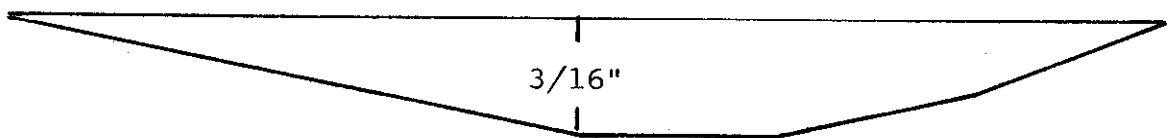
Figure 10: Wheel Path Cross Sections - 1979



I-80 Eastbound near Coralville



I-80 Eastbound near Iowa City



I-80 Eastbound near West Branch

Figure 11: Wheel Path Cross Sections - 1979

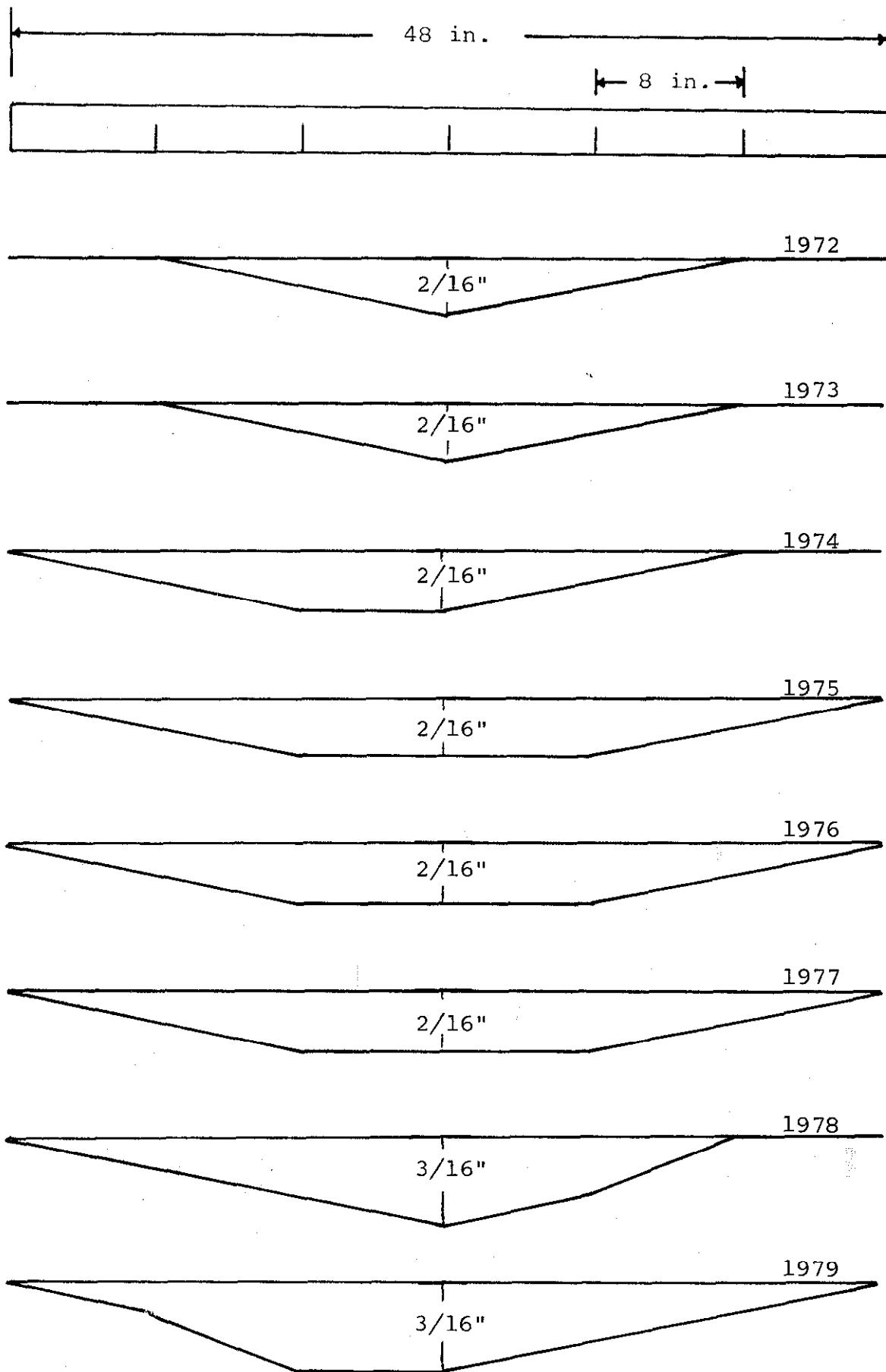


Figure 12: Progression of Wheel Path Wear - Station 885+00
Near Iowa City

As the wheel path becomes wider, it can be observed that the outer edges of the wheel path begin to wear causing the zero point, the end of the straightedge, to become lower in relation to the center of the wheel path (Figure 13). When this occurs, the total wear can no longer be measured accurately with the 4 foot straightedge.

As illustrated in Figures 7 through 11, the maximum wear reported is $\frac{5}{16}$ inch. It must be remembered that this is an average of three (3) readings four (4) feet apart, therefore, it does not mean that there are not places deeper than the resulting average. In fact, depths of $\frac{3}{8}$ inch and $\frac{7}{16}$ inch may be observed at selected locations.

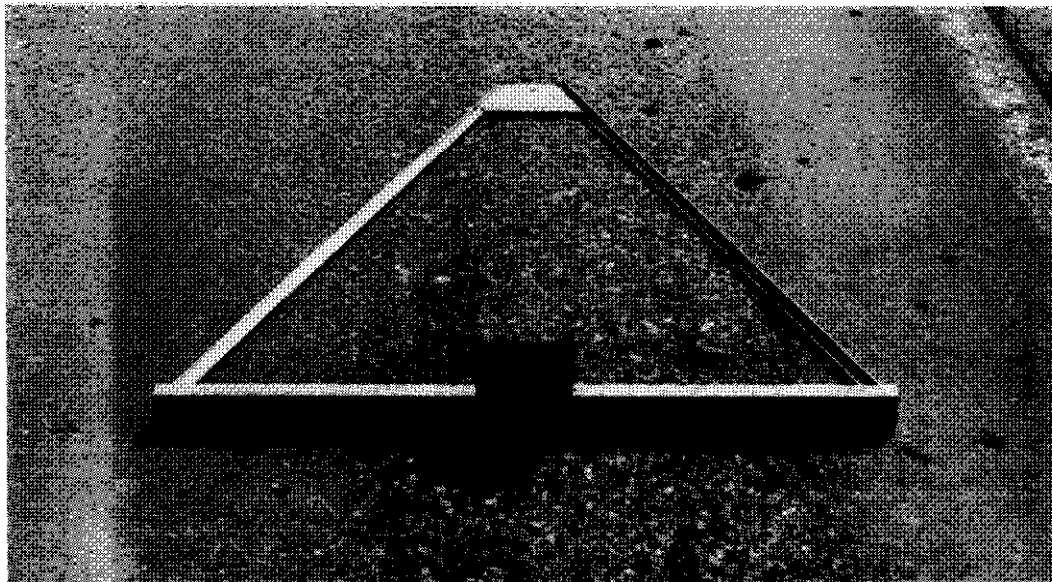


Figure 13: Widened wheel path

SAFETY HAZARDS

Several unsafe conditions are effected by the use of studded tires. If a motorist places enough confidence in studded tires to drive 5 miles per hour faster than he would without studs, in terms of stopping distance, he is no better off than without studs.

Safety hazards such as premature loss of pavement lane markings, reduction in driving visibility due to increased splash and spray from water accumulating in rutted wheel tracks, hydroplaning, adverse steering effects caused by rutted wheel tracks and improper lateral placement of vehicles to avoid worn wheel tracks are all contributed to by wear caused by studded tires.

CONCLUSIONS AND RECOMMENDATIONS

Tire studs were introduced and sold on the basis of being a safety benefit to the motoring public. However, facts and conclusions of scientific studies have revealed that this equipment is creating more safety hazards than safety benefits (References 1, 2 and 3). The conditions when studded tires may offer safety benefits exist only about 1% of the time while the rest of the time the studs may increase stopping distance.

The safety aspects of the studs may be negated that 1% of the time because of overdriving. The small margin of braking

benefit offered by studs can be nullified by an over-confident driver with an increased speed of only five (5) miles an hour.

Studded tires have worn ruts in the Iowa pavements as deep as 5/16". As ruts develop due to studded tire wear, water does not properly drain from the surface. During warm months, water collects in the ruts and creates an unsafe condition conducive to hydroplaning. Splash and spray from the accumulated water also reduces driver visibility.

During the winter months, snow and ice cannot be removed from the rutted wheel path. This causes motorists to travel closer to the center line or edge of the pavement to avoid the snowpacked wheel path.

Because of the foregoing conclusions, it is recommended that studded tires be banned in Iowa.

ACKNOWLEDGEMENTS

The efforts of the Iowa DOT field personnel that made the parking lot studded tire surveys and the Office of Planning personnel that made the moving vehicle counts are greatly appreciated. A big thank you to the Iowa DOT Maintenance people for traffic control provided while making the wear measurements.

REFERENCES

1. "Studded Tire Fact Sheets", Department of Transportation and Communications, Ontario Canada, October, 1971 Edition.
2. "The Effects of Studded Tires", Minnesota Department of Highways, March, 1971.
3. "Laboratory Evaluation of Pavement Damage Caused by Studded Tires, Salt and Abrasive Sand", Supplemental Report. Test 5A/B, Minnesota Department of Highways, June, 1971.
4. "Studded Tire Use in Iowa", Position Paper #6, Iowa State Highway Commission, October, 1973.

APPENDIX

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
10.3	Alta	14	89	15.7	1	8.8	47,605	4189
6.6	Armstrong	5	73	6.8				
10.1	Emmetsburg	19	245	7.8				
6.0	Estherville	43	444	9.7				
11.1	Milford	3	80	3.8				
8.9	Spencer	29	510	5.7				
8.4	Spirit Lake	13	150	8.7				
5.5	Storm Lake	53	445	11.9				
17.4	Akron	4	69	5.8	2	8.7	60,969	5304
11.1	Alton	7	57	12.3				
8.5	Aurelia	5	53	9.4				
7.3	Cherokee	58	397	14.6				
3.6	George	8	60	13.3				
11.1	Hartley	4	81	4.9				
15.0	Hawarden	17	142	12.0				
7.1	Hull	4	78	5.1				
11.9	Kingsley	5	55	9.1				
5.8	Le Mars	27	393	6.9				
7.6	Marcus	6	63	9.5				
7.6	Orange City	13	170	7.6				
8.5	Paullina	4	64	6.3				
11.6	Remsen	6	73	8.2				
9.7	Rock Rapids	9	132	6.8				
11.2	Rock Valley	5	108	4.6				
6.9	Sanborn	7	70	10.0				
8.6	Sheldon	15	220	6.8				
5.7	Sibley	11	130	8.5				
13.6	Sioux Center	10	167	6.0				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
9.7	Moville	3	36	8.3	3	14.6	54,846	8008
7.9	Sioux City	341	2328	14.6				
22.2	Denison	72	370	19.5				
24.7	Dunlap	18	81	22.2				
26.2	Harlan	45	319	14.1				
5.5	Holstein	11	95	11.6				
4.3	Ida Grove	11	140	7.9				
13.6	Lake View	6	86	7.0	4	14.8	47,584	7042
28.6	Logan	14	90	15.6				
17.0	Mapleton	20	116	17.2				
17.6	Missouri Valley	30	211	14.2				
18.6	Odebolt	7	87	8.0				
11.8	Onawa	36	211	17.1				
13.5	Sac City	18	195	9.2				
22.1	Woodbine	18	73	24.7				
12.3	Avoca	11	76	14.5				
19.2	Council Bluffs	343	1851	18.5	5	17.5	46,588	8153
19.3	Oakland	6	127	4.7				
23.5	Bedford	6	85	7.1				
12.6	Clarinda	25	278	9.0				
12.9	Glenwood	51	226	22.3				
18.3	Hamburg	16	83	19.3				
6.7	Lenox	6	63	9.5				
16.4	Malvern	2	60	3.3	6	13.1	37,963	4973
21.0	Mount Ayr	11	91	12.1				
23.6	Red Oak	50	322	15.5				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
13.6	Shenandoah	28	320	8.8	6 (cont)			
20.0	Sidney	10	59	16.9				
17.1	Villisca	13	73	17.8				
6.0	Adel	33	216	15.3	7	11.2	48,827	5469
9.9	Audubon	13	180	7.2				
19.4	Carroll	104	517	20.1				
16.7	Coon Rapids	16	80	20.0				
7.4	Dallas Center	3	65	4.6				
8.5	Guthrie Center	12	105	11.2				
13.4	Jefferson	56	708	7.9				
20.4	Manning	14	95	14.7				
3.3	Perry	18	400	4.5				
3.3	Waukee	7	90	7.8				
1.6	Woodward	5	60	8.3				
10.2	Fort Dodge	126	1460	8.6	8	7.2	60,053	4323
3.7	Gowrie	2	117	1.7				
8.5	Humboldt	18	447	4.0				
5.2	Jewell	1	63	1.6				
14.0	Lake City	6	86	7.0				
5.0	Laurens	8	90	8.9				
16.5	Manson	4	91	4.4				
12.5	Pocahontas	16	122	13.1				
8.0	Rockwell City	6	106	5.7				
5.9	Webster City	27	375	7.2				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
4.3	Algona	19	427	4.4	9	8.8	41,645	3665
4.0	Bancroft	5	80	6.3				
7.5	Britt	22	143	15.4				
4.8	Buffalo Center	3	76	3.9				
7.2	Forest City	42	258	16.3				
7.2	Garner	24	152	15.8				
3.8	Lake Mills	10	154	6.5				
12.3	Manly	10	114	8.8				
9.4	Northwood	11	136	8.1				
8.4	Osage	12	257	4.7				
11.8	Ackley	11	96	11.5	10	7.7	61,834	4761
8.3	Allison	4	78	5.1				
6.7	Belmond	9	227	4.0				
13.3	Clarksville	7	76	9.2				
9.2	Clarion	17	268	6.3				
5.7	Denver	9	74	12.2				
5.5	Eagle Grove	13	234	5.6				
6.2	Eldora	12	187	6.4				
11.7	Greene	8	134	6.0				
10.1	Grundy Center	13	141	9.2				
8.1	Hampton	13	226	5.8				
4.8	Iowa Falls	25	329	7.6				
3.1	Parkersburg	10	85	11.8				
7.2	Reinbeck	11	91	12.1				
10.0	Sheffield	1	57	1.8				
4.6	Shell Rock	1	61	1.6				
6.6	Sumner	20	115	17.4				
6.9	Tripoli	16	81	19.8				
6.4	Waverly	27	402	6.7				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
4.8	Ames	47	1190	3.9	11	6.6	49,226	3249
7.4	Boone	64	508	12.6				
2.3	Huxley	1	42	2.3				
6.5	Madrid	11	117	9.4				
6.8	Nevada	15	175	8.6				
1.2	Ogden	9	175	5.1				
0	Slater	0	46	0				
3.4	Story City	6	67	9.0	12	8.8	179,604	15805
2.1	Altoona	8	81	9.9				
8.4	Ankeny	17	250	6.8				
5.4	Des Moines	592	6677	8.9				
5.0	Mitchellville	6	41	14.6				
13.8	Colfax	8	104	7.7	13	11.0	46,213	5083
9.6	Marshalltown	126	1022	12.3				
8.8	Monroe	11	70	15.7				
7.7	Newton	60	621	9.7				
9.4	Prairie City	4	48	8.3				
3.9	State Center	7	96	7.3	14	6.4	44,739	2863
2.0	Carlisle	7	112	6.3				
3.8	Indianola	25	448	5.6				
6.4	Knoxville	10	355	2.8				
6.3	Oskaloosa	33	487	6.8				
3.2	Pella	33	306	10.8				
4.5	Pleasantville	2	60	3.3				
5.9	Norwalk	10	100	10.0				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
1.2	Albia	15	297	5.1	15	8.6	40,846	3513
3.2	Bloomfield	8	296	2.7				
1.0	Centerville	22	396	5.6				
6.4	Chariton	28	300	9.3				
12.1	Corydon	9	112	8.0				
3.1	Keosauqua	7	78	9.0				
7.0	Lamoni	26	189	13.8				
2.7	Leon	18	137	13.1				
14.9	Osceola	38	186	20.4				
3.8	Burlington	39	1128	3.5	16	3.4	50,662	1723
4.1	Fort Madison	13	440	3.0				
4.6	Keokuk	18	495	3.6				
14.1	Mediapolis	1	49	2.0				
3.3	West Point	2	36	5.6				
6.3	Columbus Jct.	3	61	4.9	17	5.3	58,463	3099
4.1	Eldon	2	59	3.4				
2.7	Fairfield	9	377	2.4				
9.9	Kalona	8	72	11.1				
4.0	Mt. Pleasant	24	295	8.1				
2.7	New London	5	75	6.7				
1.1	Ottumwa	58	1208	4.8				
11.1	Wapello	3	78	3.8				
7.2	Washington	14	259	5.4				
0	Wellman	9	52	17.3				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
7.6	Belle Plaine	13	177	7.3	18	9.9	50,905	5040
16.3	Brooklyn	7	85	8.2				
12.0	Dysart	5	78	6.4				
9.5	Grinnell	81	630	12.9				
1.4	Keota	7	82	8.5				
4.4	Marengo	8	136	5.9				
8.6	Montezuma	5	80	6.3				
7.0	Sigourney	23	148	15.5				
14.6	Tama-Toledo	44	429	10.3				
21.7	Traer	5	102	4.9				
6.0	Vinton	28	298	9.4	19	7.7	76,946	5925
9.7	Williamsburg	7	113	6.2				
6.5	Hudson	2	65	3.1				
13.0	LaPorte City	5	72	6.9	20	17.8	58,120	10345
8.3	Waterloo- Cedar Falls	236	3000	7.9				
27.6	Calmar	24	125	19.2				
13.6	Cresco	21	221	9.5				
22.5	Decorah	84	462	18.2				
23.3	Elkader	32	98	32.3				
6.5	Fayette	17	140	12.1				
24.3	Guttenberg	37	168	22.0				
35.1	Lansing	21	68	30.9				
41.8	Monona	17	88	19.3				
8.7	Nashua	14	118	11.9				
7.5	New Hampton	13	204	6.4				
5.6	Oelwein	74	461	16.1				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
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20.0	Postville	19	87	21.8	20 (Cont.)			
8.5	Strawberry Pt.	15	90	16.7				
29.3	Waukon	71	293	24.2				
6.5	West Union	44	202	21.8				
12.9	Cascade	6	68	8.8	21	8.1	68,636	5560
8.8	Dubuque	138	2041	6.8				
11.0	Dyersville	26	202	12.9				
16.7	Epworth	3	41	7.3				
2.2	Farley	3	41	7.3				
3.1	Independence	24	206	11.7				
2.9	Jesup	7	75	9.3				
6.5	Manchester	21	157	13.4				
6.3	Cedar Rapids	191	3641	5.2	22	5.3	97,346	5159
4.5	Center Point	2	42	4.8				
10.0	Central City	4	34	11.8				
6.3	Lisbon	0	38	0				
6.7	Mount Vernon	6	89	6.7				
3.2	Durant	0	48	0	23	4.7	71,202	3346
5.3	Iowa City	80	1698	4.5				
9.0	Muscatine	35	704	5.0				
9.3	North Liberty	3	34	8.8				
5.1	Tipton	4	99	4.0				
5.0	West Branch	2	48	4.2				
11.9	West Liberty	4	70	5.7				
12.0	Wilton	2	62	3.2				

1976-77 % Studded Tires	City	1977-78 Survey Data			Area Number	Sampling Area Result		
		Vehicles w/ Studded Tires	Total Vehicles Surveyed	% Studded Tires		% Studded Tires	Vehicle Registrations	No. Vehicles w/ Studded Tires
17.3	Anamosa	10	163	6.1	24	3.1	53,749	1666
8.9	Bellevue	2	173	1.2				
1.8	Camanche	4	160	2.5				
4.7	Clinton	30	1273	2.4				
3.0	DeWitt	6	140	4.3				
7.5	Maquoketa	11	240	4.6				
7.4	Monticello	7	138	5.1				
3.2	Bettendorf- Davenport	128	3427	3.7	25	3.7	89,479	3311
9.3	Anita	8	63	12.7	26	10.6	32,702	3466
12.0	Atlantic	40	407	9.8				
11.8	Corning	5	110	4.5				
16.2	Creston	47	443	10.6				
7.0	Greenfield	13	115	11.3				
20.0	Griswold	4	60	15.0				
13.1	Winterset	33	216	15.3				
8.4	Charles City	19	350	5.4	27	6.6	40,955	2073
6.3	Clear Lake	15	231	6.5				
6.2	Mason City	73	1088	6.7				
8.0	Nora Springs	6	52	11.5				
				Totals		8.5	1,617,707	137,743